RAYLASE GmbH is providing a jump-start to the topic of e-mobility by giving manufacturers of battery cells, battery packs and battery modules a power charge in innovation.

> "I could either watch it happen or be a part of it"
>
> Elon Musk

Just recently, in an impassioned speech, President of the European Commission, Ursula von der Leyen, called for a show of strength from the Union in the fight against climate change. According to the European Commission, EU pollutant emissions are to be reduced "by at least 55 percent" by 2030. The UN climate agreement signed in Paris in 2015 commits the international community to limiting global warming to below 2°C Celsius, including a significant reduction in climate-damaging emissions.

Hardly any other aspect of climate protection is being so intensely and hotly debated as the topic of transport, and hardly any other is as significant, since its contribution to the issue is so huge. Unfortunately, the positive CO_2 effects of more consumer-friendly engines have been undone in recent years with the registration of more and heavier vehicles. What is needed now is a leap in innovation.

Sources: Federal Ministry for Economic Affairs and Energy BMWi Electric mobility and Battery cell production, European Battery Alliance, RAYLASE GmbH, Handelsblatt, elektro-auto-news.net, statista.de, Fraunhofer Battery Alliance, umweltbundesamt.de, electrive.net, ADAC, SZ 17.9.20

The market

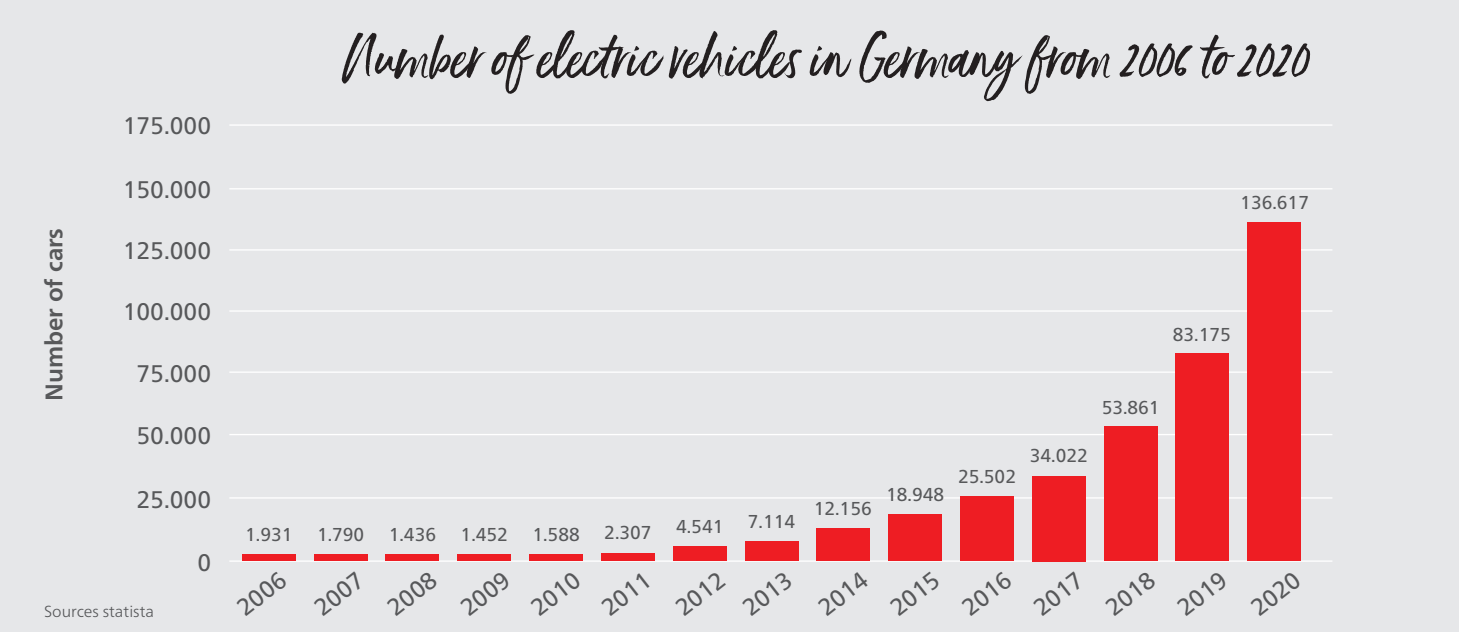
e-mobility and the key players

Electrification is currently regarded as the key to reducing climate-damaging emissions in the transport sector worldwide. This is because electric vehicles - in conjunction with regeneratively generated electricity - produce significantly less CO_2 than conventional drive systems. This is also confirmed by a current study carried out by the Technical University of Eindhoven on behalf of the Green Party in the summer of 2020, according to which electric cars currently being sold are responsible for lower CO_2 emissions than internal combustion engines, even taking into consideration battery production and power consumption. In addition, they can absorb fluctuations in wind and solar power by storing energy and thus help the erratic energy of renewable sources to establish itself on the market.

THE TIME HAS COME FOR ELECTRIC MOBILITY

In addition to e-mobility in the public sector - especially rail, tram and bus connections not to mention e-bikes - the entire transport sector - cars, trucks, ships and even aeroplanes - is facing a huge shift towards electrification. But for a long time, it seemed as though the consumer, and car manufacturers even more so, had no interest in letting go of the internal combustion engine. The year 2017 finally saw Germany pass a definitive tipping point. In the wake of the diesel scandal, more and more car manufacturers offered their customers a premium for switching to an electric car. The year 2020 also seemed to be a good one for e-vehicles: around 61,100 new cars were registered between the beginning of the year and July. No wonder more and more manufacturers are adding e-vehicles or hybrid vehicles to their product range. There is a wide range of electric car models from national and international manufacturers currently on the market, such as the Porsche Taycan, BMW i3, Audi e-tron quattro, Renault Mégane eVision, Kia e-Niro and Tesla models, to name but a few. Start Ups like Sono Motors, Lucid and Rivian or NIO quickly catch up and offer competitive new technology and will further speed up the shift to electric powered transportation.

And the German government is also clearly steering in the direction of e-mobility. To make the use of electric vehicles more attractive, it decided on 18 May 2016 to give additional impetus to e-mobility. The overall package consists of purchase incentives limited until 2025, the so-called environmental bonus, additional funds for expanding the charging infrastructure, a procurement programme for the public sector and extensive tax measures. The vision is to rethink mobility holistically, with all its components such as drive technology, battery research, energy research, networked cars, fleet and logistics concepts, digitalisation, network



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integration and intelligent billing of electricity at charging points, and the associated infrastructure. By 2030, the federal government wants to increase the number of charging points to one million as part of the so-called „Master Plan for Charging Infrastructure".

IS THE FUTURE LOOKING BRIGHT FOR E-CARS?

E-mobility is transitioning from being an industry driven by subsidies to one that is growing due to real customer demand and supportive political mechanisms, according to Bloomberg NEF analyst Colin McKerracher. Many analysts are positive about the future. Growth drivers are likely to be the decreasing battery prices which are simultaneously increasing in effectiveness. The trend is also moving towards significantly lower lithium consumption. Correspondingly, McKinsey predicts there will be 100 million electric cars worldwide by the year 2040 in their intermediate scenario. And the hype is only just beginning.

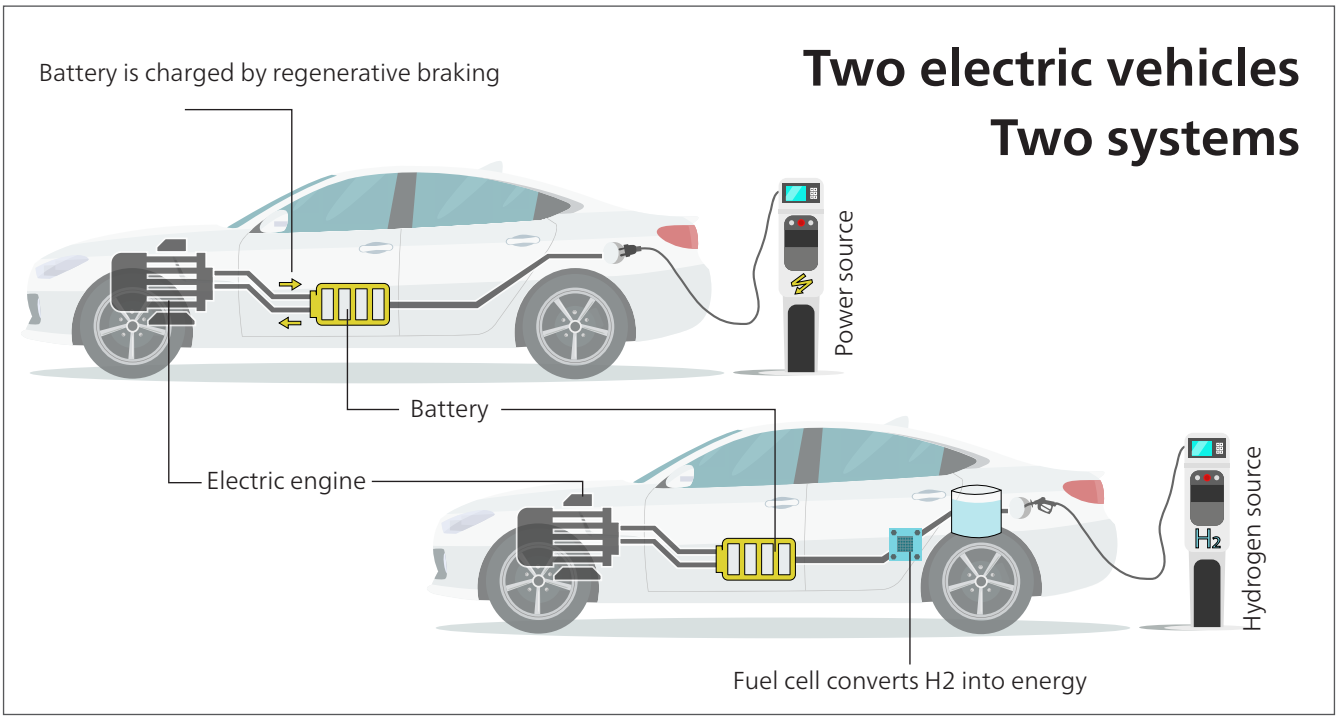
THE EUROPEAN BATTERY ALLIANCE BRINGS NEW DRIVE

At the heart of e-mobility are powerful, state-of-the-art batteries. To counterbalance the dominance of the Americans and Asians in the field of battery production, the Europeans have founded a battery alliance. The timing seems to be right, as China is currently cutting many subsidies. The Federal Ministry of Economic Affairs and Energy (BMWi), under the leadership of Federal Minister Peter Altmaier, wants to develop Germany within the framework of this alliance into a leading location and is making one billion euros available by 2022 from the Energy and Climate Fund for this purpose. The goal is to make the domestic market the leading market for electric mobility. After all, e-mobility can only be truly successful with state-of-the-art batteries offering advanced storage capacity and fast charging options.

> *"One day, everything will run on batteries, cars, ships, trains and even aeroplanes"*
>
> Federal minister, Peter Altmaier

GERMAN INDUSTRY HAS HEARD THE WAKE-UP CALL

Almost every day, new reports are coming in. The e-mobility market is developing rapidly. Brand new alliances are needed now to maintain Germany's technological leadership, to



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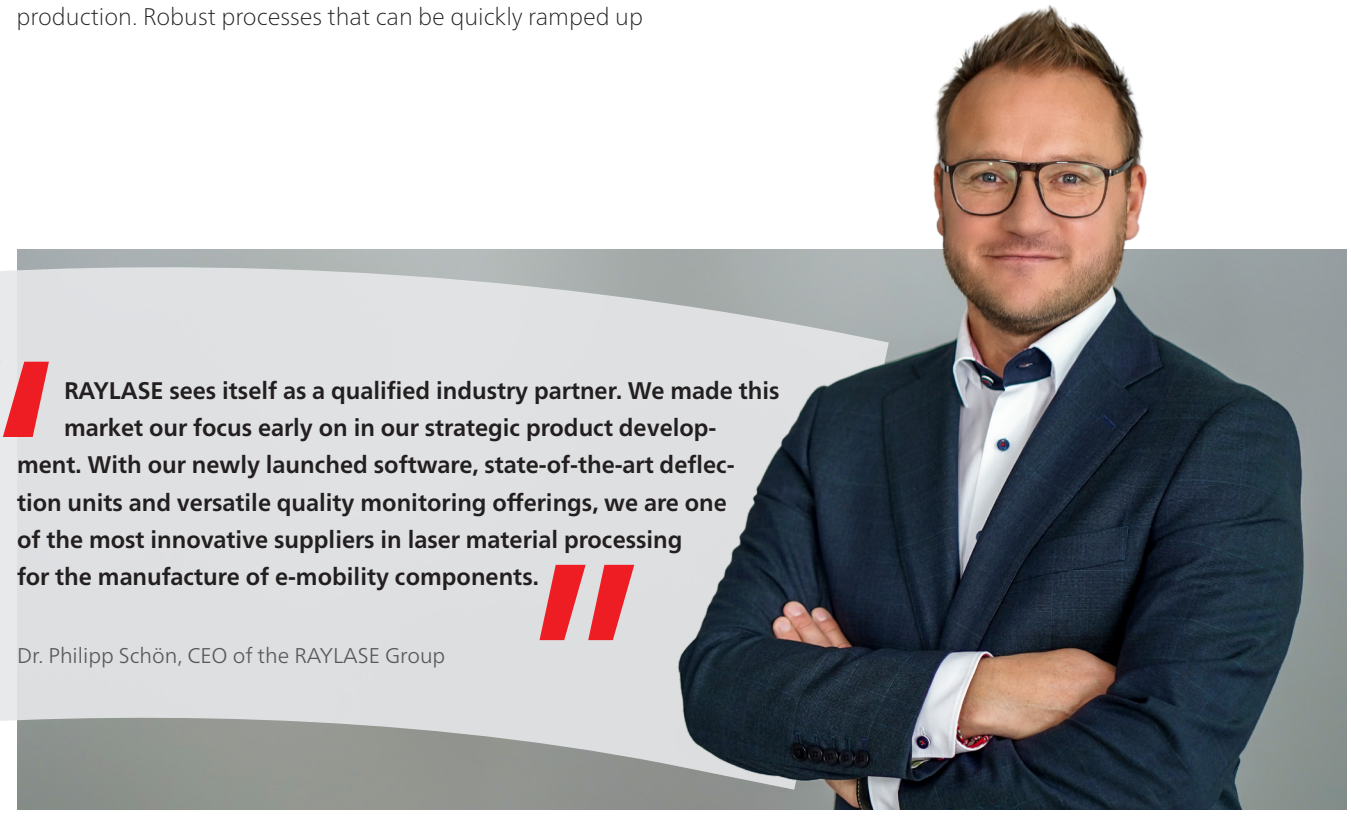
charge their electric vehicles at home and to successfully market them on the world market. Globally, automobile companies and manufacturers of battery technologies are currently forming joint ventures. In August 2020, Daimler announced its cooperation with battery supplier CATL, VW took a 26% stake in Guoxuan and BMW is currently setting up its own „E-drive systems competence centre" in Dingolfing. As a result, huge gigawatt factories are being built, like Tesla's battery production in Brandenburg, whose output of the relevant components is expected to cover the gigantic energy requirements of the coming decades.

AT THE HEART OF EVERY BATTERY IS THE BATTERY CELL

Battery cells are the core component of every battery. In the case of electric cars, up to 40 percent of the added value comes from battery cells. Unfortunately, there are no standardised cell formats yet. The 7.9 million electric cars produced worldwide until 2019 contained lithium-ion batteries in three main cell formats: cylindrical, prismatic and pouch. The most common is the round or cylindrical cell as used in the Tesla M3. It is used flexibly in the form of many packs covering the entire underfloor compartment of electric cars. The prismatic cell used in the BMW i series - i3 and i8 - for example, is rectangular and considered the safest cell format. Pouch cells, on the other hand, are cheaper to produce, but can also be less safe as they are more flammable.

LASER TECHNOLOGY IS A KEY COMPONENT OF E-MOBILITY

On route to the mass market for e-mobility, it is not only German industry that needs innovative technologies for series production. Robust processes that can be quickly ramped up from today's low production volumes are in high demand. Laser material processing plays a significant role. Essential elements of this are the lasers themselves and critical system components such as laser deflection units, optics, sensors, quality monitoring and digital control systems. Laser material processing is a key component in manufacturing for e-mobility. This process is used in the manufacture of essential components, including among others the electric drive itself, the manufacture of battery cells, modules and packs, and finally the necessary power electronics. Laser material processing makes it possible to manufacture the battery in an efficient, contactless and affordable way at maximum capacity and with maximum flexibility at the same time. "RAYLASE sees itself as a qualified industry partner. We made this market our focus early on in our strategic product development. With our newly launched software, state-of-the-art deflection units and versatile quality monitoring offerings, we are one of the most innovative suppliers in laser material processing for the manufacture of e-mobility components", says Dr. Philipp Schön, CEO of the RAYLASE Group. With more than 14,000 deflection units produced and delivered in 2020, the Bavarian company from Wessling is one of the largest suppliers worldwide.



"RAYLASE sees itself as a qualified industry partner. We made this market our focus early on in our strategic product development. With our newly launched software, state-of-the-art deflection units and versatile quality monitoring offerings, we are one of the most innovative suppliers in laser material processing for the manufacture of e-mobility components."

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RAYLASE GmbH - innovative partner

in e-mobility production

"Electric mobility involves processes such as drying, cleaning, structuring, cutting and above all welding. These are some of the strategic applications offered by RAYLASE which open up a very large application field for our company in the e-mobility market. Because it is often modern laser technology using deflection units which offer the most efficient and cost-effective solutions."

Wolfgang Lehmann
RAYLASE product manager

Successful collaboration

RAYLASE works closely with customers in the following three applications which form the core of electric mobility:

1

Inside the battery

Cutting electrode foils for battery production

2

Outside the battery cells

Contact welding different battery cell formats

3

Producing battery packs and modules

Welding aluminium components

In addition to the three application fields mentioned above, laser systems with deflection units are also used in other areas: for plastic separator foils for safely separating electric potentials in battery cells, for power electronics for converting and distributing electrical energy, for electric engines and fuel cells and, in future, for dry coating electrode foils.

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Application 1

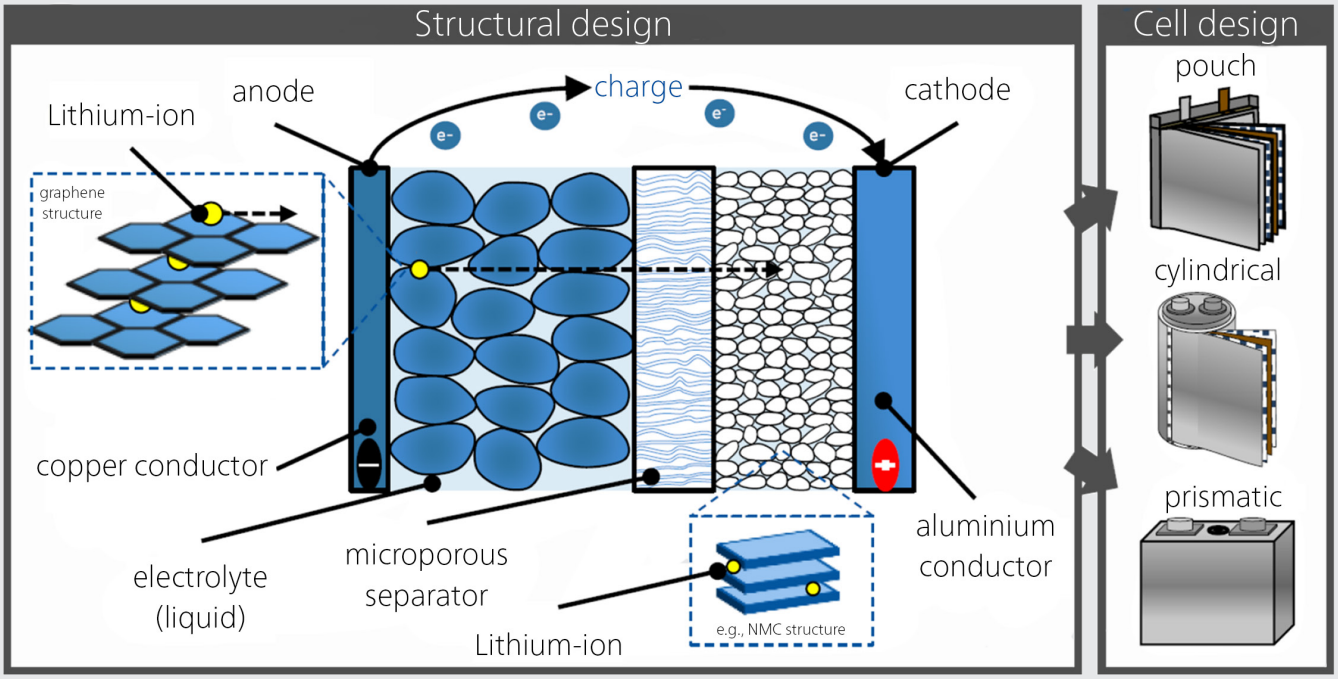
Laser cutting electrode foils for battery production

Much currently depends on efficient battery production in the industry since faster and more precise manufacture leads to enormous cost savings in production. Modern laser technology is proving to be an innovative driver from which electric mobility can only gain. The manufacture of lithium-ion battery cells essentially involves three production steps:

electrode manufacture, cell assembly and cell finishing.

Electrode production and cell finishing can be carried out largely independently of cell type, while for cell assembly a distinction is made between pouch, cylindrical and prismatic cells. Regardless of the cell type, the smallest unit of every lithium-ion cell consists of two electrodes, namely a coated foil for the anode (copper) and cathode (aluminium) and a microporous separator made of plastic that separates the electrodes from each other. In between is the ion-conductive electrolyte.

Working principle of a lithium-ion battery cell



Electrode manufacture → **cell assembly** → **cell finishing**

Source: VDMA in cooperation with the University RWTH Aachen

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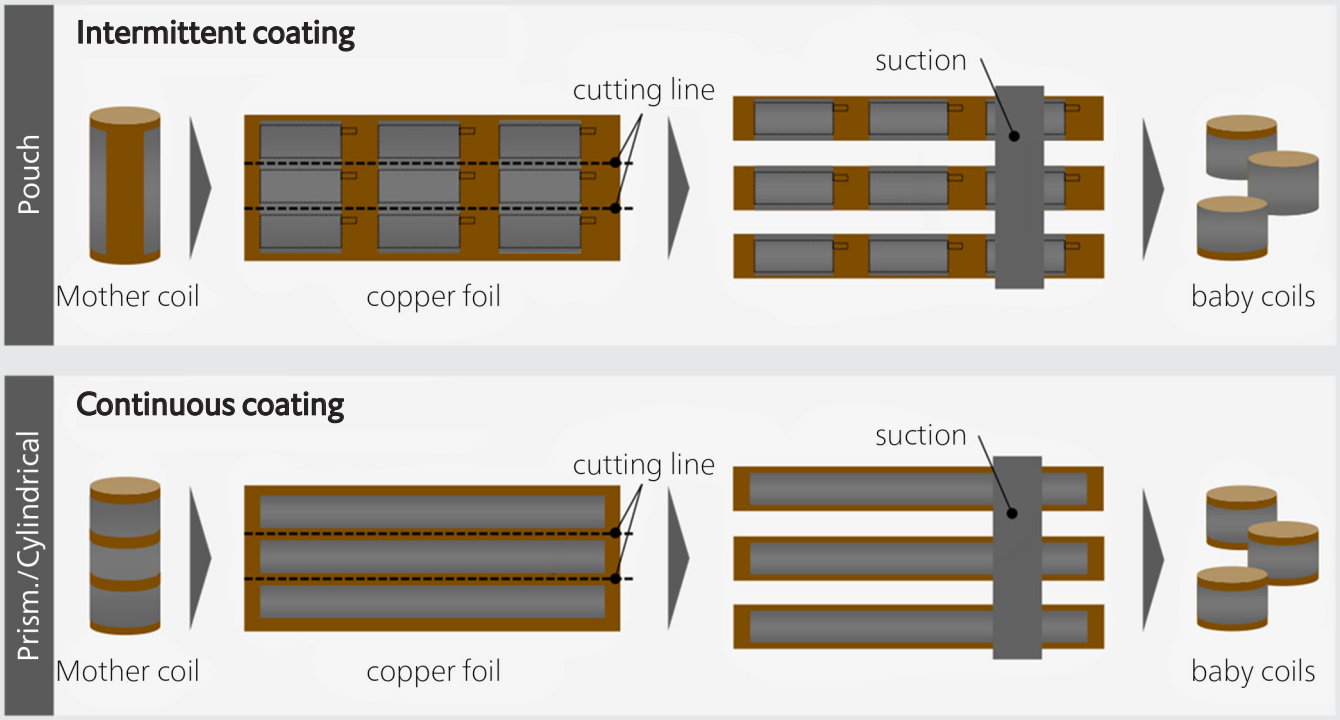
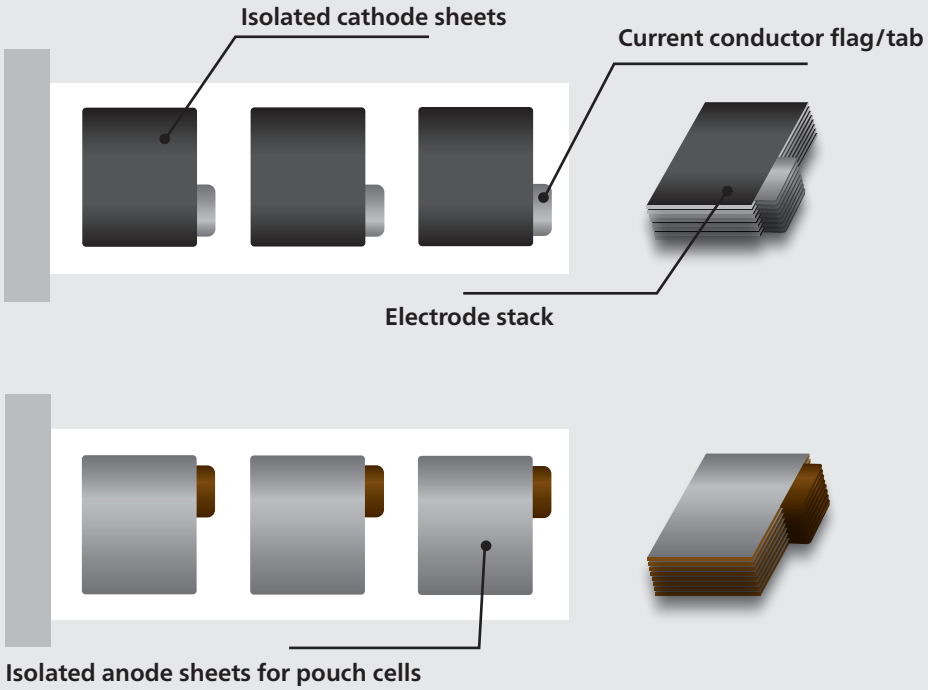
Electrode manufacture



Source: RWTH Aachen University

In electrode manufacture, carrier foils made of aluminium and copper are then coated with electrode material on large so-called mother coils and, after drying and rolling, separated into baby coils. For pouch cells, these are already divided into areas onto which an intermittent coating is applied, which later roughly correspond to their cell size. In contrast, the round cylindrical and prismatic cells have a continuous coating. The baby coils made of coated aluminium and coated copper usually have a thickness of approx. 5-25 µm each and must now be separated to the desired format of the cells.



Not only the coated areas are cut with high precision using the laser beam deflection system. Punching may still be the norm at present, but modern laser systems also offer clear advantages here. For example, the deflection unit allows for both a very straight cut to be made on the coating and the corresponding current conductor flags to be generated quickly and precisely using contour cutting.

To increase productivity in this process step, cutting of the battery foils and generation of the foil stacks of pouch cells are usually carried out with the baby

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coil running. For cylindrical and prismatic cells these are called foil wraps. A highly complex process that requires the highest precision at the greatest possible speed. And a task in which modern laser cutting systems can show all their benefits. With the help of the appropriate software and exact consideration of the conveyor belt speed, laser deflection units can perform the cut with precise positioning at astonishing speed. And in contrast to conventional punching tools, the laser is completely wear-free.

Pre-focusing laser deflection units in the appropriate process field sizes that perform the cutting process with a very fine spot and high contour quality are particularly suitable for this production step. Deflection units with large mirror apertures in the range of 50mm - such as those employed by Berlin company Jonas & Redmann, a global manufacturer of specialist machinery - are useful here. This company develops and produces machines and products for assembly technology, medical technology, photovoltaics and not least, for energy storage in the form of battery cells.

Axel Albrecht, General Manager for Laser Technology at Jonas & Redmann and an expert in the field, sees the advantages this way:

Source: @Jonas & Redmann Group GmbH

"From cell production to the assembled, ready-to-install battery pack, there is an enormous number of individual production steps, each of which influences overall productivity and output of manufactured units. Laser technology has made itself indispensable because, among other things, we can use it to minimize maintenance on the machines and so keep our customer's manpower to a minimum. With the help of pre-focusing deflection units from RAYLASE, we are also able to achieve a very high-quality laser cut on the electrode foils to be separated while the foil roll is running."

Source: @Jonas & Redmann Group GmbH

Sources: Federal Ministry for Economic Affairs and Energy BMWi Electric mobility and Battery cell production, European Battery Alliance, RAYLASE GmbH, Handelsblatt, elektro-auto-news.net, statista.de, Fraunhofer Battery Alliance, umweltbundesamt.de, electrive.net, ADAC, SZ 17.9.20

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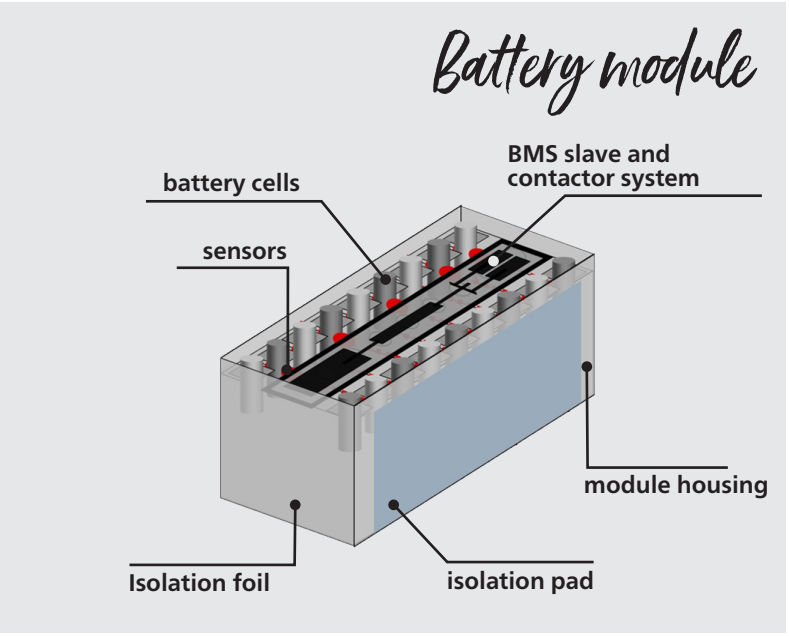
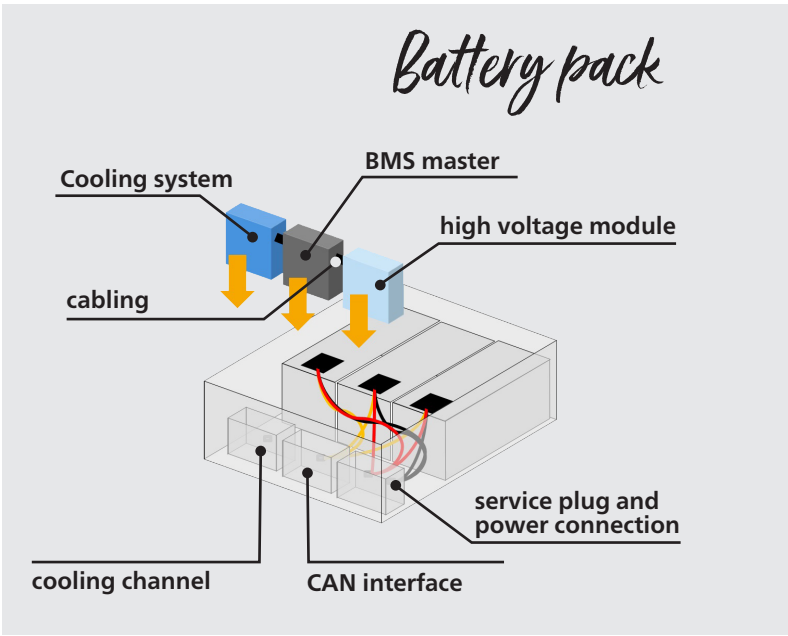
Application 2

"Tab welding" and "cell connector welding" different cell formats

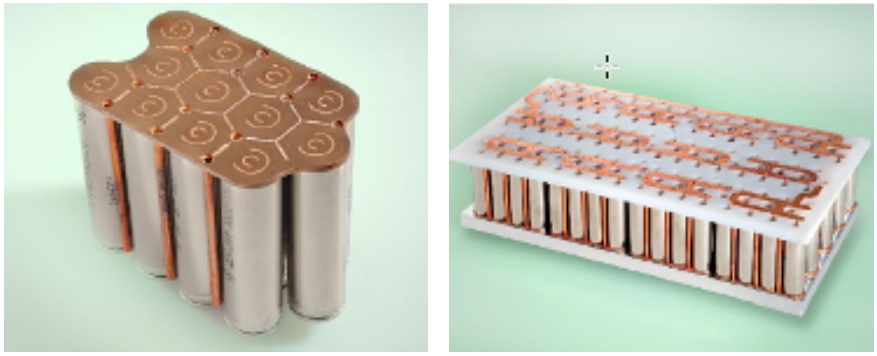
Another important application area for modern laser systems in e-mobility is the field of "welding". It is known that a battery should fully charge as quickly as possible, have the highest possible charge capacity and the longest possible range. But wherever electricity flows, there is always electrical resistance. Under certain circumstances, these can drastically limit the efficiency of the battery. Especially when many individual small battery cells or submodules are connected in series to form a larger cell network such as a "pack" or "stack", such small contact resistances can quickly add up to a large total resistance. And that should be avoided.





The individual cells are interconnected in series or in parallel in a module. Several modules and other electrical, mechanical, and thermal components together make up a battery pack.
Source: VDMA in cooperation with RWTH Aachen University

"Depending on the type of cell, the poles of the cells are connected in parallel into submodules or in series to form battery packs. The quality of the weld is therefore always an indication of the quality of the through-hole plating and thus the contact resistance. The better the weld, the lower the resistance! If errors occur during this process in the welding process, for example if the cell is not sufficiently welded to the contact material, then considerable wastage occurs because the rest of the already welded cells have become unusable." says RAYLASE CEO Dr. Philipp Schön. Therefore, it all depends on the high-precision welding of the individual cell formats.



Sub-module and battery pack of cylindrical cells

CYLINDRICAL CELLS – OPTIMALLY THROUGH-PLATED, OPTIMALLY WELDED

Cylindrical cells in the currently used 18650 or 21700 designs are first connected in parallel across a wide area via conductive plates to increase the available storage capacity. Because of its very high conductivity, copper is used for the conductive plates. They form a submo-

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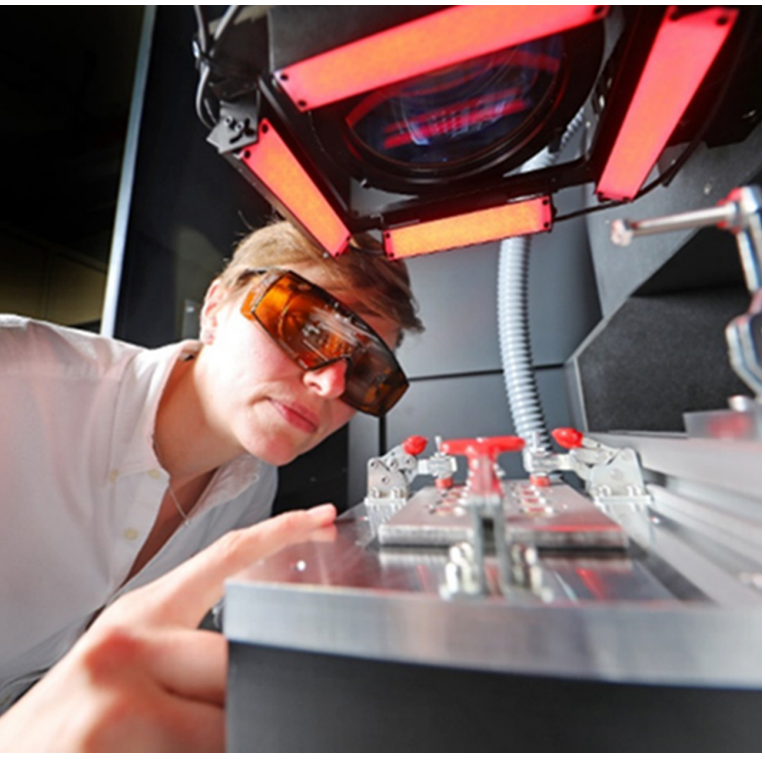
dule that is connected in series with other submodules in the form of a battery pack in a shared casing. The laser welding process is fundamental because exact welding depth is important when dealing with extremely thin contact plates.

The series connection of the cells now makes it possible to add up the source voltages of the submodules. These units can be controlled with other cell networks e.g., in the underfloor compartment of an electric vehicle, and further connected as required via the power electronics. Despite the high complexity, the individual work steps can be controlled in a stable and regularly repeatable way with the help of laser deflection units.

Above all, laser micro welding with laser deflection units offers an optimal welding process without mechanical force. In the case of cylindrical cells, deep welding processes, in particular, are used in which the laser beam penetrates both sheets to be welded with a very small spot diameter but remains in the lower sheet with a defined welding depth. A so-called "keyhole" is formed, a welding capillary that fills up with the liquefied metal mixture and cools down as soon as the laser beam moves away. To increase the connection area to a precisely defined value, the laser beam is modulated or wobbled here.



An employee from the Fraunhofer ILT in Aachen checks the settings of the scanner system. Below is a clamping device for a sub-module of cylindrical cells.
Source: Fraunhofer ILT Aachen

Suitable deflection units therefore have both a high jumping speed from contact point to contact point and a high wobbling speed with very good positioning accuracy. "For this, among other things, deflection units are used that have been specially developed by RAYLASE to be optically, dynamically and mechanically optimised for these applications. The controls and electronics are also individually designed for these purposes." In this production step, the single mode or single mode near laser is used.

Another special challenge in the field of laser welding is the welding of so-called „dissimilar" materials. In the case of cylindrical cells, these are the copper current conducting plates in connection with the aluminium poles of the cells. The different degrees of absorption of the metals also result in different melting behaviour which complicates the process. New wavelengths in the green (515nm, 532nm) and also the blue wavelength range at 450nm seem to offer more favourable absorption behaviour of the materials, which can make the welding process even more homogeneous and of higher quality. Ongoing research is being carried out here to make the processes even more efficient.

All in all, the design of the welding process consisting of the scan parameters and ultimately the quality control using suitable sensors, is hugely important in e-mobility. Accordingly, the various welding work steps require absolute precision work. It almost always requires the connection of coaxial process monitoring that functions via the deflection unit's mirror system. The connected sensors are often different. The control electronics are also indispensable, as they provide a variety of real-time functionalities especially for the requirements of e-mobility processes.

"For example, our laser software offers an excellent customer interface for the control electronics. If required, it can also provide an intuitive and highly functional process configuration interface that clearly maps out the processes to be carried out and records their execution with a precisely positioned time stamp,"

says RAYLASE product manager Wolfgang Lehmann, explaining the unique features of his company's product.

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POUCH CELLS – LASER WELDING IN SERIES PRODUCTION

Heat conduction welding is usually used for pouch cells. This is always possible when the tabs or contact flags are thick enough to provide a very robust welded connection with relatively high laser power. The heat conduction process results in a weld bead width of several 100 micrometres. Here, too, the tabs of the pouch cells are made of different materials, namely aluminium or copper, depending on the pole.

A cell network of pouch cells. These are arranged side by side in battery packs and welded in series using so-called "tabs". Each individual pouch cell already has so much storage capacity that no further parallel connection of cells is necessary.

However, due to the more generous space available with pouch cells, multi-mode lasers up to 6kW and additional redundant welds can be used. It enables a high-quality connection without significant contact resistances.

A pouch cell. The "tabs" are clearly visible as contact flags.
Source: Fraunhofer Battery Alliance

Once again, the laser deflection unit with its unique properties is the most suitable tool. It enables all welds to be carried out in one position and in one laser process field. „With our pre-focusing deflection units in particular, process fields the size of the battery packs can be easily reached," Harnesh Singh, Sales & Marketing Director at RAYLASE emphasizes in describing the benefits of laser welding.

PRISMATIC CELLS – WELDING CELL CONNECTORS

Like the pouch, the prismatic cells are installed side by side. In contrast to the former, the through-hole plating is done with so-called „cell connectors". The expert understands this to mean welding an aluminium cell connector onto the aluminium contact surfaces of the prismatic cells. Mostly multi kW lasers are used and modulated heat conduction welding is applied.

Indispensable: In all processes, reliable and meaningful monitoring contributes to high-quality, waste-free production. This can be done using a camera to check the position or by using welding monitoring systems currently available on the market which work by measuring light intensity via the deflection unit's mirrors.

On the right, the cell connector. The welding takes place on the inside of the round opening of the cell connector.

Sources: Federal Ministry for Economic Affairs and Energy BMWi Electric mobility and Battery cell production, European Battery Alliance, RAYLASE GmbH, Handelsblatt, elektro-auto-news.net, statista.de, Fraunhofer Battery Alliance, umweltbundesamt.de, electrive.net, ADAC, SZ 17.9.20

International collaboration

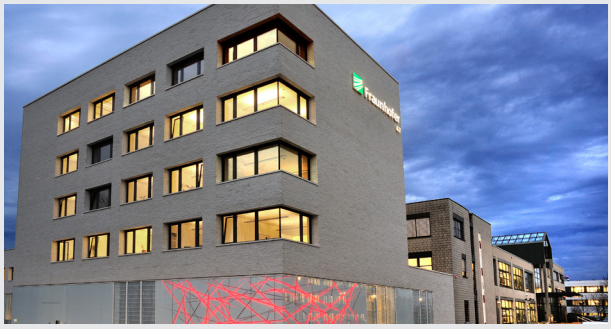
RAYLASE GmbH in the e-mobility sector

The British "TWI Welding Institute" specialising in "welding processes" in e-mobility works with the AXIALSCAN-50 DIGITAL II from RAYLASE for laser welding.

RAYLASE has been cooperating with national and international universities and institutions for several years now in order to understand new process requirements and implement them in the best possible way as new customized products. What they have in common is their dedication to researching the processes involved in e-mobility and their user-oriented industrialization.

TWI's specialist expertise in joining technologies and growing experience in EV battery manufacture have been supporting the automotive industry with the development of laser welding procedure specifications (WPSs) for busbar to terminal and module frame joints, validation on live assemblies, series prototype production (involving both assembly and welding) and End-of-Line (EOL) quality checks. Laser beam scanning techniques, combined to in-process quality assurance sensor technology, have been used to achieve a flexible and precise process. Clear advantages include welding speed and the ability to focus the laser beam to a few tens of micron spot size, achieving the necessary power densities required to couple into highly reflective materials, such as those used to make busbar substrates'.

The Fraunhofer Institute for Laser Technology ILT in Aachen is also an acclaimed institution. Here, too, research is being carried out on e-drive systems: „Battery electric vehicles represent a central pillar in a new era of mobility that will no longer rely on the use of fossil fuels. This is reflected in the growing numbers of electrical storage devices in production." Dr. Alexander Olowinsky, Group Leader for Micro-joining at ILT, is certain: "It's hard to imagine battery technology without the current laser-based manufacturing processes. Particularly for building battery modules and packs that consist of large numbers of cells, laser technology can play to its strengths, which include high flexibility and good controllability of the energy input for the connection. "Dr. Olowinsky sees challenges in process stability and quality: „Online process control in combination with scanner-based beam guidance systems will be the way to achieve high quantities at the required process speeds," he says, emphasizing the value of using lasers for e-mobility.



One of the most renowned institutions in Germany is the Fraunhofer Institute for Laser Technology in Aachen
Source: Fraunhofer ILT, Aachen

Sources: Federal Ministry for Economic Affairs and Energy BMWi Electric mobility and Battery cell production, European Battery Alliance, RAYLASE GmbH, Handelsblatt, elektro-auto-news.net, statista.de, Fraunhofer Battery Alliance, umweltbundesamt.de, electrive.net, ADAC, SZ 17.9.20

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Application 3

Laser welding aluminium components on battery packs

Another and no less important application area for laser deflection units on battery packs comprises the various welding applications on aluminium components. They are joined together and to each other using laser technology.

These sometimes very thin aluminium components place high demands on the welding process. Great flexibility is required to generate complex welding contours while simultaneously ensuring high positioning accuracy. The challenge is also to process very large laser process fields with just one laser unit with a very fine spot size.

Intelligent welding ramp functions on the control electronics ensure that the energy input into the join partners always produces a uniform welding result. The welding depth should always be constant and consistently monitored.

Special deflection units which connect suitable welding monitoring systems coaxially via the mirrors of the deflection unit, appear to be the means of choice here for monitoring and safeguarding process quality.

Depending on the material thickness of the aluminium components, CW lasers, i.e., continuous beam lasers with up to 6kW of laser power, are usually used. The laser power must be introduced into the material by the laser deflection unit in a stable way. In certain applications, the laser beam is also modulated - wobble welding - to optimise the homogeneity of the weld bead during a heat conduction welding process and to increase the bonding surface area between the components. However, non-modulated heat conduction welding and deep welding processes can also be suitable for this.

DANA

VICTOR REINZ®

Sealing Products

A renowned user of welding processes for joining aluminium components using RAYLASE deflection units is the company REINZ-Dichtungs-GmbH. The company employs over 1000 people and is a subsidiary of Dana Incorporated. Under the brand name VICTOR REINZ, Dana develops and produces a wide range of innovative sealing technology products with the highest quality standards for the automotive industry.

Kurt Höhe, Project Manager Laser Welding at REINZ remembers the first uses of this technology that is so vital for e-mobility: “Several years ago, we began using scanner-based laser applications to weld stainless steel and aluminium components together with high precision. Today, laser scanners help us limit machine complexity and enable high process speeds in large work fields, while still maintaining high component quality. Another advantage of using aluminium components is the lightweight construction of the units and, at the same time, the high component rigidity. RAYLASE supported us here from the start of the planning phase for the corresponding applications right up to the implementation phase in existing and new production facilities. Short reaction times, willingness to test new technologies together and open collaboration are still characteristics of our partnership. The company helps us to meet the demands of the “VICTOR REINZ” brand again and again in developing the most innovative production technologies as an automotive supplier.“

Sources: Federal Ministry for Economic Affairs and Energy BMWi Electric mobility and Battery cell production, European Battery Alliance, RAYLASE GmbH, Handelsblatt, elektro-auto-news.net, statista.de, Fraunhofer Battery Alliance, umweltbundesamt.de, electrive.net, ADAC, SZ 17.9.20

We're on board

TOGETHER WITH RAYLASE INTO A SUSTAINABLE, ELECTRIFYING FUTURE

Thanks to the diverse deployment of lasers with deflection units, electric mobility is now also on a direct route to the mass market. They support this by reducing cost pressure and promoting series production. Much is at stake for German industry, but not being a global player in the market is no longer an option. Because those who don't jump on board now will miss the boat. For far too long, international carmakers have clung on to the internal combustion engine, hesitated and dithered. In view of the huge size of the China market, whose omnipotent President Xi Jinping adopted a 10 percent quota for electric vehicles in China last year, no one can escape this trend anymore.

But this is only one argument as e-mobility is simply an indispensable ingredient for a better future. RAYLASE CEO Dr. Philipp Schön is convinced of that: "It must be in our interests to leave behind a world for the next generation which has learned to treat our environment in a way that is sustainable and conserves resources. If we view the path to this energy shift holistically, we will succeed in reaching the climate targets we set. This approach includes generating energy using photovoltaics, using battery power to store energy, and converting energy using electric drives. For me, the sign of the times clearly indicates an electrifying future. And we will make an important contribution to the future in these three areas ".

Conclusion

In view of climate change and the associated need to reduce our overall CO_2 footprint, particularly in the transport sector, the course is set ecologically, politically, and economically for electric drive systems. If we want to avoid handing over this important territory to the Asian market, now is the time for German industry to invest in e-drive systems.

Headquaters:
RAYLASE GmbH
Wessling, Germany
+49 8153 9999 699
info@raylase.de

RAYLASE